REAL-TIME PLUTONIUM, CURIUM, AND AMERICIUM MONITOR

TECHNOLOGY NEED

The goal of this project is to develop and deploy an on-line monitor that will measure in real time the concentrations of various metal oxides in a molten glass stream. In general, it will have the capability of measuring any transuranic in a vitrification process stream. We are presently working with the Americium-Curium Stabilization Project at the Savannah River Site, so the device is being tailored to measure americium and curium to satisfy their Site Technology Coordination Group (STCG) Need SR-5003. Their baseline technology for monitoring the vitrification stream is off-line analysis, principally inductively coupled plasma (ICP). The baseline technology requires sampling the stream, transporting the highly radioactive sample to the laboratory, analyzing the sample, and then disposing of it or storing it. This technology is safer, faster, and cheaper because it provides an analysis in real time without contacting the glass stream.

TECHNOLOGY DESCRIPTION

The monitor uses the spontaneous thermal emission spectrum of the molten glass stream to measure the stream composition. It passively observes this spectrum through a fiber-optic cable so that the instrument can be mounted outside the radiation zone, and it uses a spectrometer based on an acousto-optic tunable filter (AOTF) that, having no moving parts, is very robust. The emission spectrum contains certain peaks that are characteristic of americium and curium oxides and whose heights indicate the concentrations of the metals. Transient infrared spectroscopy, an innovative technology that is a variant of conventional thermal emission spectroscopy, was found to be inferior to the conventional method during a site test in FY 1997 (see Accomplishments), so the conventional method is now being developed for the vitrification application.

BENEFITS

This monitor provides both cost and safety benefits while improving control of the vitrification process. It is anticipated that the on-line monitor will reduce the number of samples that will have to be taken and analyzed off line. Each off-line sampling and analysis is expected to cost $50,000 to $100,000 and require about one week. Once installed and calibrated, the monitor will provide analyses automatically at negligible cost in less than one minute without contacting the radioactive material. This immediate information feedback will alert the vitrification operators to problems or unexpected conditions so that they can be efficiently dealt with.

CAPABILITIES/LIMITATIONS

The thermal emission spectrometer can use near infrared spectroscopy to monitor in real time the concentrations of transuranics and many other metal oxides in molten glass streams or pools up to roughly one-half inch thick. The related technique of transient infrared spectroscopy uses mid-infrared spectroscopy and has been used to monitor the concentration or state (e.g., cure level) of a much wider variety of components (both inorganic and organic) in a very wide range of solid and viscous liquid process streams of any thickness below approximately 300 °C. Once set up and calibrated, both technologies are largely automatic, requiring little operator intervention. A fully assembled near-infrared thermal emission spectrometer should cost about $15,000.

COLLABORATION/TECHNOLOGY TRANSFER

We have collaborated with two end-user groups at the Savannah River Site on applying the on-line monitor to their vitrification process stream. In FY 1997, we demonstrated the first version of the monitor for the staff of the Glass Formulation and Vitrification Process Development Task for the Plutonium

Immobilization Program (see Accomplishments below). Since the cancellation of that vitrification task, we have worked with the Americium-Curium Stabilization Project, and we then tailored the device for monitoring americium and curium in molten glass, instead of plutonium. The thermal emission spectroscopy technology is readily adaptable to monitoring all actinides. The start-up of the canyon facility for Americium-Curium vitrification is scheduled for January 2000. The final version of our monitor will be included in that facility. Several demonstrations and tests at Savannah River with the Americium-Curium Stabilization Project will occur before that. The first of these demonstrations is scheduled for the summer of 1998.

Thermal emission spectroscopy is a mature technology and the principal components of the monitor are commercial devices, so no efforts toward commercialization have been made. The Iowa State University patents for the transient infrared spectroscopy technology are US Patents Nos. 5070242, 5075552, and 5191215.

ACCOMPLISHMENTS

During FY 1997, the first year of the project, a monitor capable of both thermal emission spectroscopy and transient infrared spectroscopy was assembled from borrowed equipment and demonstrated at Savannah River for the staff of the Glass Formulation and Vitrification Process Development Task for the Plutonium Immobilization Program. The monitor was mounted on a small glass melter that produced very short glass pours (1 to 2 minutes), but the monitor was sufficiently fast to measure the stream with both thermal emission and transient infrared spectroscopy analyses during a single pour. Ytterbium was used as a surrogate for plutonium because the two have near-infrared features of similar size and position. The thermal emission approach gave better results and is simpler than transient infrared spectroscopy; consequently, thermal emission was selected for further development.

TECHNICAL TASK DESCRIPTION (TTP) INFORMATION

TTP No./Title: CH17C232 - Real-Time Plutonium Monitoring by Transient Infrared Spectroscopy

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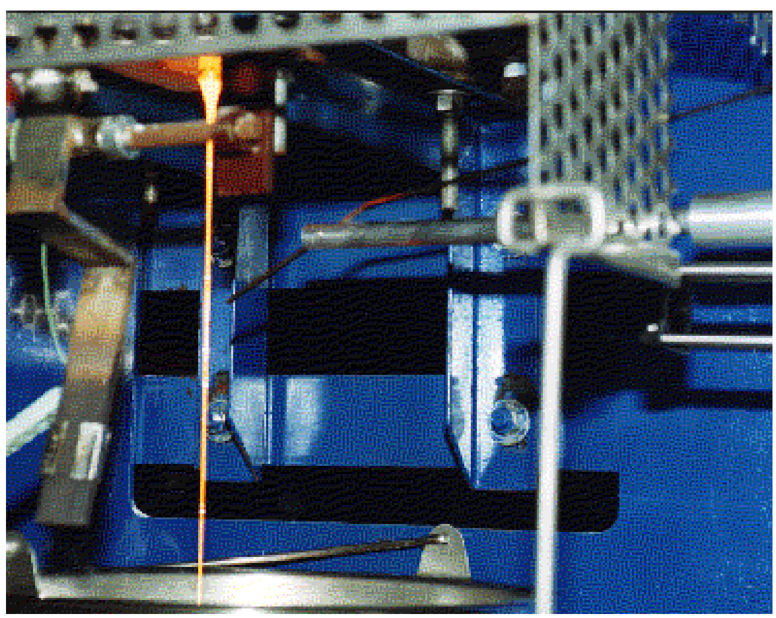

The thermal emission spectra of elements in a molten glass stream are monitored by Transient Infrared Spectroscopy.